

# Climate and Settlement of the Arid Region

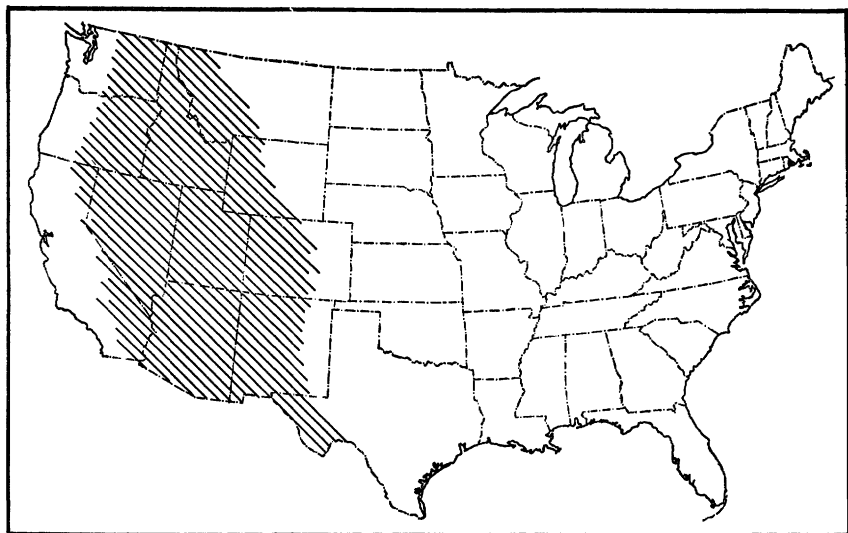
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GAMBLING ON the climate may be possible in semiarid regions, but the dweller in an arid region has to play safe or perish. He learns to know where the water is, to husband it, to use just the right amount when it is needed, to protect his watersheds; and by this skill, knowledge, and discipline, he makes rich gardens in the desert. Theoretically; but theory and the practice do not always dovetail, and no type of agriculture has stricter requirements than irrigation farming.

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NOWHERE in the United States has climate influenced the patterns of settlement and culture more definitively than in the arid region of the West. Together with topography and soils, it has determined rather rigidly the location of most settlement, whether in individual farms, rural communities, or larger population centers. It has even largely conditioned settlement incident to mining. Within relatively narrow limits, it has restricted the number of people that the region as a whole can support, and as a result many rural communities already are experiencing population pressures of fairly severe intensity. It has been primarily responsible for the development of irrigation, a distinctive and highly specialized type of agriculture. Finally, it has given rise to certain basic problems inherent in an environment where man has had to utilize meager resources to the fullest possible extent and resort to specialized techniques and disciplines in order to make agricultural development possible and settlement a success.

## GENERAL CLIMATIC CHARACTERISTICS

The arid region comprises a broad belt of mountain, valley, and desert land some 600 miles wide and nearly 1,100 miles long lying between the western margins of the Great Plains and the crests of the Sierra Nevada-Cascade barrier, which extends along a north-south axis from Canada to the Mexican border. Within its boundaries are found the driest areas of the North American continent; in fact, general aridity is the predominant characteristic of the regional climate as a whole. There is, however, a great diversity of local climates ranging between the extremes of humid cold and torrid dry. These wide local variations are due primarily to topography but also depend to some extent on general air circulation, the relative position in the continental land mass, and latitude.

On the basis of general climatic characteristics the region can be divided into two major zones: (1) A southern zone, comprising most

of New Mexico, Arizona, and the southeastern part of California, and (2) a northern zone, including, roughly, the area between the Utah-Arizona line and the Canadian border.

In the southern zone the summer winds sweep over the region from a southerly direction and are relatively moist, causing the period of maximum precipitation to coincide with the hottest months of the year. Nearly half of the annual precipitation occurs during July, August, and September, preceded and followed by very dry periods. In the mountains and higher plateaus, however, there is a period of winter maximum in addition to the wet summer period. The winter precipitation falls principally in the form of snow. For the section as a whole the mean annual precipitation ranges from a low of 3 inches in the vicinity of Yuma to a high of more than 30 inches in the mountains of northern Arizona and New Mexico. Temperatures in general are high, with great daily fluctuations.

The northern section lies in the zone of prevailing westerly winds and receives its climatic characteristics from the cyclonic storms which sweep from the west. Maximum precipitation comes in the winter and early spring months, the summer months of July, August, and September being usually very dry. August is often rainless in valleys, as in the Boise Valley in Idaho. Mean annual precipitation for the section as a whole ranges from a low of about 4 inches in the desert valleys west of Salt Lake to highs of over 60 inches in the mountains of central Idaho and central Washington. For a contrast of precipitation patterns for the northern and southern zones see figure 1. The temperatures exhibit extremes characteristic of the continental climatic type.

Growing seasons are variable but generally shorter in the arid valleys of the northern zone than in those of the southern zone. Yakima, Wash., has 183 frost-free days; Boise, Idaho, 169; Logan, Utah, 155; whereas Albuquerque, N. Mex., has 196, Phoenix, Ariz., 295, and Yuma, Ariz., 355.

## INFLUENCE OF TOPOGRAPHY ON CLIMATE AND SETTLEMENT

The factor that significantly alters the general climate of the region is topography. Within any latitudinal zone, topography largely determines the precipitation pattern in space, just as general air circulation determines it in time. The Sierra Nevada-Cascade mountain crests rising to a maximum elevation of about 14,000 feet act as a barrier to eastward-moving storms and are responsible for much of the relatively heavy precipitation on the west slopes and the aridity of the Great Basin and the Columbia River Plateaus. Similarly each successive mountain range eastward acts in turn to increase precipitation on the western slopes and to make for greater aridity on the slopes and valleys to the east. It is not uncommon to find some valleys receiving only 4 to 5 inches of precipitation, while mountain slopes less than 40 miles away receive in excess of 40 inches. The influence of topography on precipitation is illustrated in figure 2, which gives mean annual precipitation values for certain points along a topographic profile from San Francisco to Denver.

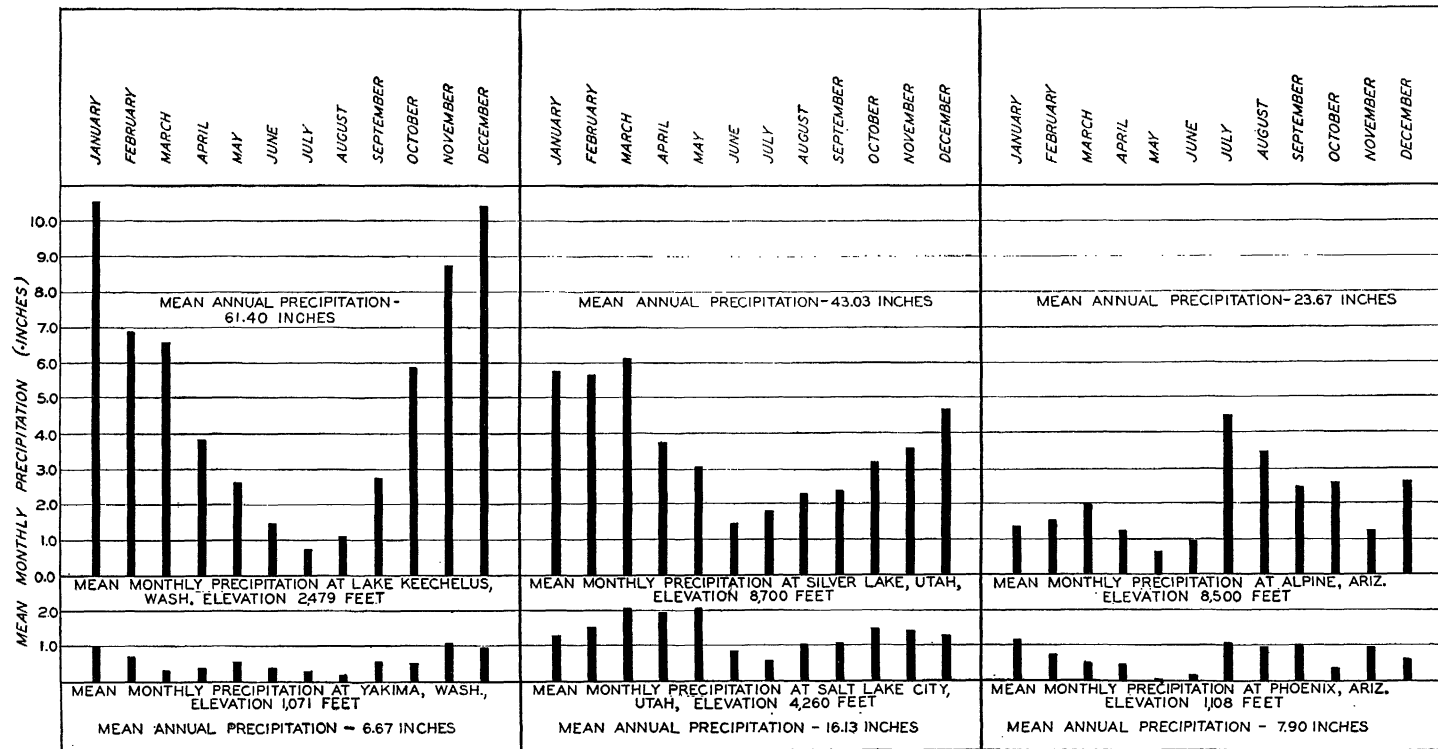


FIGURE 1.—Valley and mountain precipitation by months at Yakima, Wash., Salt Lake City, Utah, and Phoenix, Ariz.

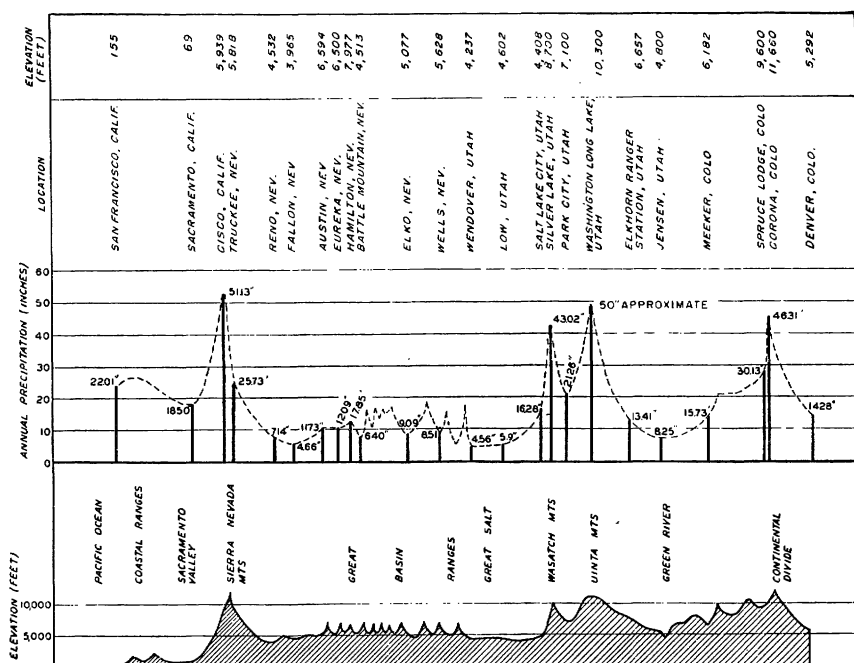


FIGURE 2.—Annual precipitation in relation to mountains and valleys along a course between San Francisco and Denver.

Topography also greatly modifies temperatures. Some valleys are not free of frost for a sufficiently long period to grow anything but the hardiest grains and forage, while others in the same latitude but at lower elevations have summer growing seasons warm enough and long enough to permit the raising of late-maturing crops, such as sugar beets, fruits, and corn.

The large and abrupt differences in precipitation and temperature induced by topography form the important feature of the climate, at least so far as human occupation of the arid region is concerned. They give rise to characteristic "humid islands" wherever mountain masses project to a substantial height above the gray, sagebrush-covered floor of the desert valleys. Many of these islands receive enough precipitation to support dense stands of ponderosa and lodgepole pine, quaking aspen, Engelmann spruce, Douglas-fir, and alpine fir, as well as a wide variety of lesser vegetation in the forests and in alpine meadows, brushfields, and woodland areas. They are cool in the summer and in the winter they are covered with snow. In fact, some of the higher areas contain snow fields that persist throughout the year.

The disproportionately heavier precipitation that falls upon the humid islands is largely responsible for generating the streams that flow into or out of the region. Moreover, snow in late fall and winter, stored for spring and summer melting, makes possible and maintains the summer flow of most streams.

The importance of this interrelationship between cool, humid mountain islands and warm, arid valleys cannot be too strongly emphasized. The islands in themselves, for the most part, are not habitable, because of steep slopes, low temperatures, rocky soils, short growing season, deep snow mantle, inaccessibility, and similar factors, but they are the gathering grounds for creeks and rivers that flow to the valleys. Indeed, one of the more striking and important features of the mountain-valley relationship is the nearness of the points between which large differences in climate may, and usually do, exist. Salt Lake City, for example, is located in the semiarid zone at the base of the Wasatch Mountains at an elevation of 4,408 feet and receives 16.13 inches of moisture annually. Forty miles west of the city the desert receives less than 6 inches of rainfall a year; 20 miles east of the city, Silver Lake, at an elevation of 8,700 feet in the Wasatch Range, has a mean annual precipitation of 43 inches. Similar relationships exist throughout both northern and southern climatic sections; these are further emphasized in figure 1, in which the three locations for which mean precipitation is given represent essentially the extremes and the midpoint of the latitudinal range of the arid region.

## THE PATTERN OF SETTLEMENT AND AGRICULTURE

With a knowledge of the climatic characteristics and the mountain-valley relationship of this region it is readily understandable why the early settlers established their homes, farms, and industries for the most part near the mouths of canyons and at the bases of mountains. These locations were selected in part because of the availability of fertile soils and favorable temperatures, but primarily because the adjacent mountains provided sources of timber for their homes, forage for their flocks, and above all, the water that was necessary for sustaining life throughout the dry summer months on the valley floors. Later, engineering developments were introduced in the form of storage reservoirs and elaborate canal systems, and these made it possible to extend settlement farther out into the valleys and away from the natural streams.

The dependence of settlement both on mountain streams originating in the humid islands and on favorable valley temperatures and soils has not only restricted the number of people that the country can support, but has rather rigidly determined the location of farms and other population centers. Today, after nearly a century of settlement, practically all of the population of the region is still concentrated where the mountain waters meet the soils of the desert valleys. A map of the arid region showing population density would strikingly illustrate how available water and soil control and determine the pattern of settlement. A concentration of population would plainly mark the course of the Snake River in Idaho and the base of the Wasatch Mountains in Utah. The effect of availability of water on population concentrations is further illustrated by the condition in Utah. Today the density of the population for that State as a whole is 6.2 persons per square mile while along the Wasatch Front from Santaquin to the north end of Cache County, in an area 2 to 10 miles

wide by 160 miles long and totaling only 1,000 square miles, or 1.2 percent of the land area, the density is 338 per square mile.

The relationship between humid islands and dry valleys is responsible for the development of an irrigation agriculture wherein crops are not dependent on precipitation that falls on the cultivated lands but on that which accumulates on the more remote range and forest lands.

Historically, modern irrigation culture began crudely in July 1847, when Brigham Young and his group of Mormon pioneers started diverting water from City Creek near the site on which Salt Lake City developed. The Mormon occupancy of the arid land is characteristic of much of the settlement that has occurred throughout the whole region, and nowhere is the relationship of the environmental factors of climate and topography to settlement more clearly pictured than in the Utah valleys. Compact villages have been established on almost every stream along the west front of the Wasatch Mountains and high plateaus. They are situated at the mouths of canyons, and around them are spread green irrigated fields which give way to the gray sagebrush landscape at the end of the ditch. From an airplane they appear as small varicolored oases in a great expanse of "desert" landscape.

The inhabitants of the irrigated valleys, living in the faith of continuing stream flow, have gradually acquired a consciousness of the dependence of the irrigation enterprise upon the mountain watersheds. In Utah it is estimated that at least 80 percent of the usable stream flow is derived from mountain lands above 7,000 feet in altitude, or generally at elevations 2,500 to 6,000 feet above the valley floor. The implication is clear when one considers that every acre of the 1½ million of irrigated land in Utah is dependent upon approximately 7 acres of range and forest watershed land.

Similar mountain-valley relationships prevail on the Snake River in southern Idaho, where agricultural developments such as those in the Boise Valley and Twin Falls sections have been made on valley plains receiving only 7 to 12 inches of precipitation annually. For their water supply these developments depend entirely upon the Boise and Snake Rivers, which originate on mountain lands comprising only 30 percent of the drainage area but receiving up to 60 inches of precipitation annually. Relationships of like character are found throughout the entire arid region.

Settlement of the arid region was also made possible by ranching and dry farming, a form of agriculture which adapted itself to the topography, native vegetation, and climate, in contrast to the irrigation enterprise, in which the environment was modified. Such development, however, has not always been independent of irrigation, for even the livestock industry has greatly expanded as a result of forage production by the artificial application of water to croplands.

Although irrigation agriculture is not the sole source of livelihood in the arid regions, it colors all other activities and determines in a large measure how far these others may develop. Table 1 gives the acreage and value of irrigated lands in comparison with the total of all agricultural lands for the 11 Western States, some of which have areas in other climatic zones.

TABLE 1.—*Acreage and value of irrigated lands in the 11 Western States*<sup>1</sup>

State	Total crop-land	Irrigated land	All farms	Irrigated farms	Value of all farm lands	Value of irrigated land
	<i>Acres</i>	<i>Acres</i>	<i>Number</i>	<i>Number</i>	<i>Dollars</i>	<i>Dollars</i>
Arizona.....	649,000	576,000	14,173	8,523	160,854,000	131,239,000
California.....	8,390,000	4,747,000	135,676	85,784	2,976,155,000	2,145,451,000
Colorado.....	8,449,000	3,394,000	59,956	31,288	510,955,000	309,266,000
Idaho.....	4,073,000	2,181,000	41,674	27,933	340,256,000	253,067,000
Montana.....	11,399,000	1,595,000	47,495	11,925	442,941,000	156,067,000
Nevada.....	484,000	487,000	3,442	3,031	53,665,000	50,145,000
New Mexico.....	1,799,000	527,000	31,404	14,347	180,721,000	73,630,000
Oregon.....	4,173,000	899,000	55,153	11,387	501,947,000	130,246,000
Utah.....	1,495,000	1,324,000	27,159	23,847	174,341,000	157,832,000
Washington.....	6,275,000	499,000	70,904	15,949	608,373,000	154,327,000
Wyoming.....	2,293,000	1,236,000	16,011	7,308	174,464,000	99,704,000
Total.....	49,489,000	17,465,000	503,047	241,342	6,124,672,000	3,640,974,000

<sup>1</sup> Data from 1930 Census of Irrigation of Agricultural Lands.

## CLIMATE AND THE PROBLEMS OF IRRIGATION AGRICULTURE

Irrigation agriculture has many advantages, but it also has many hazards which constantly threaten its permanency.

Theoretically, irrigation affords an ideal form of husbandry wherein man attains a high degree of control over his crops through regulation of water, averts the consequences of drought, and takes advantage of the long, warm growing seasons and fertile soils of the semidesert valleys to produce high yields in a variety of crops. Actually, however, the realization of all these benefits is difficult, for the whole process is beset with many important problems.

Experience with floods and erosion in the arid West, together with knowledge, gained through research, of the factors affecting run-off and soil stability on mountain watersheds, shows the dangers that threaten irrigation and the necessity of establishing and maintaining a sound watershed-management program based on knowledge of the factors determining the quantity and quality of water delivered to the irrigated lands.

Upon invading the arid West, settlers found that the normally low summer flow of the streams did not furnish enough water for their needs. Accordingly dams and elaborate diversion works were constructed in order to conserve winter and spring run-off and to convey water to the thirsty soils. In addition, people took to the hills to dig mine shafts, to cut timber, to graze flocks, and to build spiraling roads to scenic and recreational areas. In doing these things, man not only altered the age-old characteristics of stream flow, but he also tampered with the equally long established physical and biological features of the watershed lands from which the water is derived. The use of watershed lands for these purposes is essential, but it must be tempered by the requirements of soil and water conservation.

The watersheds where the streams originate can be so impaired by improper use that the character of the natural stream regimen is changed, resulting in increased frequency and destructiveness of floods and siltation. Moreover, through improper irrigation and land-management practices, the application of these mountain waters can damage and has damaged the soils by the leaching of plant foods,



increased erosion of the topsoil, concentration of salts beyond the toxic tolerance of the plants, accumulation of stagnant water in soil horizons, and the sealing of pore spaces essential to plant growth in the soil. Locally these destructive processes already presage the downfall of irrigation agriculture if they are allowed to spread unchecked.

Perhaps the most serious problem in irrigation is that of alkali. Soils in an arid region generally contain large quantities of alkali salts, formed in the process of weathering. The rainfall is insufficient to wash them away or leach them out. Application of irrigation water quickly concentrates the more soluble salts at or near the surface of the soil. Alkalinity is also associated with waterlogging, when too much water is added to the soil and the water table is raised into the root zone of field crops, not only "drowning" the plants but increasing the salt concentration above the tolerance of the species grown.

In certain instances concentration of salts in streams flowing through arid territory may reach such a high point as to make the water unsuitable for use in ordinary methods of irrigation. Moreover, salt concentrations in reservoirs may become so great that the disposal of the resultant brine is a major problem.

Overexpansion and inadequate planning for settlement and land use have created other serious problems. On some projects more land has been brought under cultivation than the available stream flow would justify; on others it has not always been possible to divert the water to the areas having the best soils.

Future expansion of irrigation depends primarily upon engineering developments. There are still many areas of fertile land, and also there is much undeveloped water, but these two elements seldom occur side by side. The problem of engineering is to bring together the undeveloped water and the fertile soils through transmountain diversion, the extension and enlargement of canal systems, the construction of additional reservoirs, and in other ways. But an enduring irrigation culture cannot be built by engineering alone. On the contrary, the permanence of the enterprise, and indeed the permanence of all agriculture in the arid region, rests upon a full understanding and an adequate solution of the basic problems of land use and water conservation.